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LIGHTENING OF RED-BURING CLAYS IN THE PRODUCTION OF CERAMIC MATERIALS

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A light ceramic, based on red-burning clay, with good decorative and technical properties has been obtained by introducing into the ceramic mix $CaCO_3$ in the form of finely dispersed waste products from sugar production.

Key words: ceramic brick, waste products from sugar production, red-burning clays, volume coloring, lightening.

Ceramic facing brick is highly durable and resistant to the atmosphere. However, it is available in only a small number of colors. Consequently, a great deal of attention is now being devoted to increasing the quality of and number of available colors for articles made of red-burning clays by introducing various additives. The technology for obtaining a light ceramic by volume coloring of clay mixes with finely ground carbonate rocks and technogenic waste products is a promising step in this direction and is of great ecological value.

Facing ceramic brick with volume coloring is a promising building material, which meets the growing requirements for aesthetics and variety for facing of buildings and structures. Its advantage over bilayer, engobed, and glazed brick is high durability, since spottiness does not appear on the surface of brick exposed to the open atmosphere and the building keeps its look. Buildings which have such brick facing do not require maintenance work for the lifetime of the brick. It is especially timely to develop the production of such brick now because of the large-scale of the construction work required to implement one of the priority national projects — “Affordable housing” — and the policy of building individual houses.

Ceramic facing brick with volume coloring can be used for finishing interior walls of foyers, stairwells, passageways, interiors, and separate architectural elements of buildings. It has promise for interior finishing of rooms in public buildings — movie theaters, clubs, cafes, stores, and schools.

The red color of ceramic brick is due to trivalent iron oxide. The lightening of ceramic with volume coloring is due to the interaction of mix components with Fe_2O_3 and the formation of brightly colored iron-bearing minerals, which bind iron oxides, during firing. Calcium oxide is one component that has this effect. During firing it forms with iron oxides bicalcium ferrite $2CaO \cdot Fe_2O_3$ and melilite, which is a solid solution of gehlenite $2CaO \cdot Al_2O_3 \cdot SiO_2$ and ferriginous åkermanite $2CaO \cdot FeO \cdot 2SiO_2$. These calcium compounds impart a light color to articles [1]. The lightness of the material of an article is increased by increasing specific surface area of the additions, careful mixing of the clay and additions, and increasing the concentration of the additions. The gas atmosphere in the kiln also has a considerable effect.

Fine chalk is known to be used as an addition to ceramic mix containing calcium oxide [1]. The possibility of obtaining ceramics with light colors based on red-burning clays and carbonate-containing waste products, such as finely dispersed waste products from sugar production when the sugar juice is refined, has been investigated.

These waste products consist of saturation residue after defection and saturation of the diffusion juice of beets in sugar production. The residue, containing finely dispersed calcium carbonate with mean particle size 4.7 – 4.9 μm, is pressed out in filter presses and shipped in the form of filter cakes with moisture content 25 – 30% to a dump [2].

In sugar production the sugar juice is purified with milk of lime, containing $Ca(OH)_2$. At the present time 93 plants produce sugar in Russia. Each plant transports tens of thousands of metric tons of carbonate-containing waste products, which are of no use in industry, to dumps. One metric ton of carbonate-containing waste product is obtained for every metric ton of sugar produced. When the mixture of juice with milk of lime is saturated with carbon dioxide, nonsugars consisting of high-molecular compounds (HMC) and colloidal substances are adsorbed on the $CaCO_3$ micelia which are formed. Most HMC are organic compounds — proteins and

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TABLE 1.

Raw materials	Content, wt.%								
	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	K_2O	Na_2O	organic inclusions	other
Carbonate-containing waste products from purification of sugar juice	3.17 – 4.21	1.28 – 2.00	0.60 – 0.76	46.92 – 47.97	0.80 – 1.36	–	–	7.10 – 8.05	35.62 – 37.71
Gorodishche red-burning low-melting clay	66.70	11.90	4.78	1.21	2.45	4.99	1.09	–	7.24

pectins with long chains. When lime purifies sugar juice a protein – pectin complex precipitates into the residue. The pectin substances retard the growth of crystals of the calcium carbonate residue, which promotes the appearance of finely dispersed precipitate. In turn, the protein – pectin complexes are hydrophilic and on dissolving in water give colloidal solutions, while the pectin compounds form a more or less strong jelly [2].

The effect of the nonsugar paste of carbonate-containing waste products on the properties of clay mixes was determined for samples of low-melting clay from the Gorodishche deposit; this clay is used at the plant in Staryi Oskol to produce ceramic brick. The chemical composition of the waste products is presented in Table 1. It was determined that the organic component of the addition plasticizes the ceramic paste, improves the technical properties (lowers the plastic strength and sensitivity of the paste to drying) at the optimal amount, and improves the physical – mechanical properties of the samples. XPA identified gehlenite, dicalcium ferrite, and melilite, which lighten the material, in the samples.

In the production of two commercial test batches (plastic molding), each batch containing 50,000 conventional bricks, a box feeder was used to add at the plant the carbonate-containing component — a highly dispersed carbonate-containing waste product obtained from the purification of sugar juice and having natural moisture content 20 – 25% — in measured quantities directly into the ceramic mix with no additional production operations. It is recommended that 12 – 14 mm in diameter granules be formed by semidry and semirigid pressing of the plastic mix in a wire-cutting brick-making press through a perforated grating and dried in a drying drum to residual moisture content 9 – 10 and 14 – 16%, respectively. In the case of semidry pressing the granules are comminuted in a rod-mill – mixer and a molding powder with the following composition is obtained (wt.%): fractions > 3mm — 20, 3 – 1 mm — 50, < 1mm — 30; in the case of semirigid molding the granules are comminuted and blended on rollers and a two-roller mixer.

In the semidry method specific pressure 40 – 45 MPa must be used to compact the samples. Drying and firing (at 1020 – 1050°C) are performed in furnace cars.

It is recommended that a plastic mix with moisture content 14 – 16 and 17 – 19% be used for semirigid and plastic molding, respectively, in wire-cutting brick-making vacuum presses and that drying be performed in drying cars to residual moisture content 3 – 4% followed by firing in furnace cars at 1020 – 1050°C.

The introduction of the optimal amount of waste products into the mix will decrease the plastic strength of the ceramic paste from 158 to 81 kPa and the sensitivity to drying from 1.18 to 0.88. After firing at 950 – 1050°C light-rose colored articles with average density 1.74 – 1.79 g/cm^3, water absorption 15%, and compression strength 18 – 20 MPa and light-yellow color with water absorption 17 – 21% and compression strength 16 – 18 MPa are obtained.

In summary, the waste products from refining of sugar juice can be used to manufacture ceramic brick where they activate the sintering process, lighten the material of the articles, and promote the utilization of waste products from sugar producers.

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